Pest Management Grants Final Report

Contract Number: 99-0226

Project Title: Rotations with Broccoli for Soilborne Disease Management in Conventional and Organic Strawberry Systems

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Rotations with Broccoli for Soilborne Disease Management in Conventional and Organic Strawberry Systems

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Abstract

This projects was initiated to test the efficacy rotations with broccoli, and lettuce on strawberry yield, root infection, systemic vascular colonization, incidence of soilborne diseases on strawberry, and pathogen survival in the soil under conventional and organic production systems; and to calculate costs and benefits of sustainable alternatives such as broccoli rotational crop to chemical fumigants and to determine their relative profitability under conventional and organic production systems. Experiments to evaluate the effects of vegetable crop rotations on soilborne disease management in strawberries were established both in the conventional and organic production systems. In one half of the plots at each site, strawberries were grown to enhance soilborne pathogens, and in the other half, replicated plots of broccoli and lettuce were grown, harvested, and the residue incorporated into the soil during spring and summer seasons of 2000. Strawberries have been planted in these plots to evaluate the effects of rotations and the results will be available by September 2001. Broccoli and lettuce have also been planted in replicated plots in the area planted to strawberries last season at both sites. This will also a simulataneous evaluation of the effects of rotations from last year on strawberry diseases and yield and soilborne pathogen reductions brought about by crop rotations.

Executive Summary

The objectives of this project were to demonstrate the effects of rotations with broccoli, and lettuce on strawberry yield, root infection, systemic vascular colonization, incidence of soilborne diseases on strawberry, and pathogen survival in the soil under conventional and organic production systems; and to calculate costs and benefits of sustainable alternatives such as broccoli rotational crop to chemical fumigants and to determine their relative profitability under conventional and organic production systems. Experiments to evaluate the effects of vegetable crop rotations on soilborne disease management in strawberries were established both in the conventional and organic production systems. Both sites in the Watsonville area had moderate levels of background *Verticillium dahliae* microsclerotia inoculum (10 microsclerotia g^{-1} soil). Since both locations are in proximity and their soil types are identical, comparative studies will provide valid data on the feasibility of this approach in these production systems. During the current year, strawberries were planted in one-half of each production system and the other half had two crops each of broccoli and lettuce. In November 2000, strawberries were planted in the area planted to vegetables this year. In January 2001, vegetables were planted in the area that was cropped to strawberries during 2000. Verticillium wilt severity (prior to rotations with broccoli and lettuce) was approximately 4-fold higher in the conventional and 2-fold higher in the organic strawberry plots than in fumigated control plots. The reduction in total and marketable yield for the season was 54 and 59%, respectively, in the conventional, and 52 and 56%, respectively, in the organic plots compared with the fumigated control plots. Much of this yield reduction was caused by Verticillium wilt that killed nearly 60% of the strawberry plants by the end of the season. Soil samples to determine treatment effects on various soilborne pathogens have been sampled and are currently being assayed. We also conducted a well-attended field day at the experimental site in Watsonville in May 2000 and explained ongoing research projects. Results of the previous project on rotation also funded by DPR were disseminated via the "Pink Sheet", the official newsletter of the California Strawberry Commission.

INTRODUCTION

Strawberry is an important horticultural crop in the state of California, with an annual farm gate value of over $750 million. Pre-plant soil fumigation of strawberry fields with methyl bromide is the prevailing production practice to control weeds, soilborne pathogens, and nematodes. The imminent loss of methyl bromide due to environmental concerns has accelerated the search for sustainable alternatives to methyl bromide. Among the soilborne pathogens, Verticillium wilt is the most important as it causes death of plants. There is no resistance against Verticillium wilt in currently grown cultivars. *Verticillium dahliae* the causal agent of wilt disease has a wide host range and is distributed in most California agricultural soils. The microsclerotia of *V. dahliae* can survive in the soil for many years. Strawberry cultivars are highly susceptible to *V. dahliae* infection, as few as 2 microsclerotia per gram of soil can result in 100% disease incidence.

In a previous study funded by DPR, we demonstrated that rotations with broccoli reduce soil populations of *V. dahliae* and incidence of Verticillium wilt on strawberry. Broccoli has many advantages. Broccoli is not susceptible to Verticillium wilt and is grown extensively in the coastal valleys. Previous field trial results have consistently demonstrated the effectiveness of management of Verticillium wilt disease in cauliflower following broccoli rotation and residue amendment. In the present study the feasibility of using broccoli rotations in both conventional and organic strawberry productions systems is being tested. The experimental objectives were to demonstrate the effects of vegetable rotations on strawberry yield, root infection, systemic vascular colonization, incidence of soilborne diseases on strawberry, and pathogen survival in soil under conventional and organic production systems and to calculate costs and benefits of sustainable alternatives such as broccoli rotational crop to chemical fumigants and to determine their relative profitability under conventional and organic production systems.

MATERIAL AND METHODS

Experimental site. Experiments to evaluate the effects of crop rotation in conventional and organic strawberry production systems on soilborne diseases are in progress at Monterey Bay Academy (MBA) at Watsonville, California. These locations are approximately 200 m apart and have not been planted to strawberries at least during the past 15 years. Since both locations are in proximity and their soil types are identical, comparative studies will provide valid data on the feasibility of this approach in these production systems. At both locations, the same commercial grower is responsible for crop production. Both locations were naturally infested with other soilborne strawberry root pathogens (*Pythium*, binucleate *Rhizoctonia*, and *Cylindrocarpon* spp.).

Treatments and experimental design. In both organic and conventional production systems, broccoli and lettuce are the rotational crops. The conventional plots are nonfumigated with control treatments fumigated with methyl bromide and chloropicrin. These new plots are in the same area where the effectiveness of rotation practices was previously demonstrated and the new plots are a significantly larger expansion of previously successful rotation treatments. The treatments were laid out in a randomized complete block design with four replications. Individual plots in both production systems consisted of six beds of 6-m length per replication. Standard grower production practices were followed during each crop cycle.

The rotational crops were transplanted during February 2000 and after harvest, all crop residues were flail shredded, air dried on the surface for a minimum of two days and incorporated into the soil using a rototiller. Four weeks after incorporation, the beds in all plots were reworked for the next crop cycle. The rotational crops were again transplanted in May 2000 and the process repeated by August. Strawberries (cv. Aromas) were planted during November in all plots (including a replicated plot fumigated with methyl bromide+chloropicrin for comparison with rotation treatments). Again standard grower production practices are being followed during the strawberry crop cycle. Soil samples to determine the densities of *V. dahliae* propagules were collected at beginning and at the end of rotational crop, and every month after the start of strawberry crop. Samples are being assayed using the modified Anderson sampler technique and semi-selective NP-10 medium.

In November 1999, strawberries were planted in other half of each production system and grower production practices were followed.

Yield and disease determinations. Twenty plants per plot were visually rated for verticillium wilt severity to monitor disease progress every other week from May. The disease severity estimate was done on the scale of 0 to 8, where 0 = healthy plant, 2 = moderately stunted, 3 = moderately stunted, slight rosette of dead leaves, 4 = moderately stunted, moderate rosette, 5 = significantly stunted, slight rosette, 6 = significantly stunted, moderate rosette, 7 = significantly stunted, significant rosette, 8 = dead plant. Yield data for marketable yield and culls were obtained in the plots once a week in both production systems at MBA.

Data analysis. Differences between treatments for disease severity and marketable strawberry yield were determined by analysis of variance, and means were compared by the least significant difference test ($P \leq 0.05$). Repeated measures analysis of variance was used to test disease severity from different treatments recorded over time. All analyses were done using SAS (release 6.12 ed., SAS Institute, Cary, NC).

RESULTS

Verticillium wilt severity (prior to rotations with broccoli and lettuce) was approximately 4-fold higher in the conventional and 2-fold higher in the organic strawberry plots than in fumigated (methyl bromide+chloropicrin) control plots (Fig. 1). Losses in total and marketable strawberry yield this year were significantly greater in both conventional (nonfumigated) and organic plots than in fumigated control in the conventional system (Figs. 2 & 3). The reduction of total and marketable yield for the season was 54 and 59%, respectively, in the conventional, and 52 and 56%, respectively, in the organic plots compared with the fumigated control plots. Much of this reduction in yield was caused by severe Verticillium wilt that killed nearly 60% of the strawberry plants by the end of the season. In an earlier study funded by DPR, we demonstrated that the inoculum density of *V. dahliae*, in the soil decreased overtime after rotations with broccoli. Soil processing in the current study initiated this year to determine densities of *V. dahliae* microsclerotia in both organic and conventional plots are currently in progress.

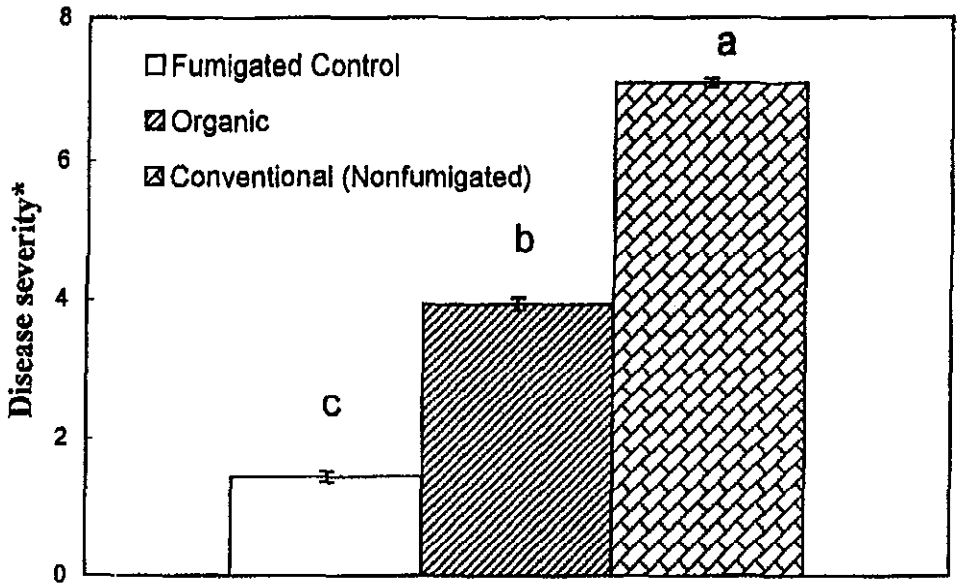
DISCUSSION

The use of these plots gives us a unique opportunity to evaluate the efficacy of rotation in both conventional and organic production systems in proximal fields. In both locations, experimentation with crop rotation is only one of several research programs exploring alternatives to methyl bromide in strawberry production. Others include alternative fumigants, methods of fumigant application, and development of microbial inoculants for reducing disease incidence. Conducting this experimentation in the same location provides an opportunity for comparison and contrasting the efficacy of the various potential alternatives to determine the most useful production practice for the grower.

SUMMARY AND CONCLUSIONS

Since the experiments are currently in progress, no definitive conclusions can be made at this time. The effects of rotations on strawberry yield, diseases, root infections, and other aspects in both conventional and organic production systems will become clearer during the ongoing strawberry crop season. The approved DPR funding for continuing this project will ensure that we can collect all necessary data to evaluate the efficacy of rotations as alternatives to soil fumigants. During the past year, we conducted one field day at the Monterey Bay Academy wherein, growers and professionals observed the destruction caused by the Verticillium wilt on strawberries. They also had an opportunity to observe rotational crops being grown to manage this and other soilborne diseases. We also summarized the results from the previous project funded by DPR in "Pink Sheet" published by the California Strawberry Commission. This official newsletter is widely distributed by the California Strawberry Commission and reaches growers, researchers, and other interested parties throughout California.

Verticillium Wilt Disease Severity of Strawberry in Organic and Convertional Production Systems in 2000

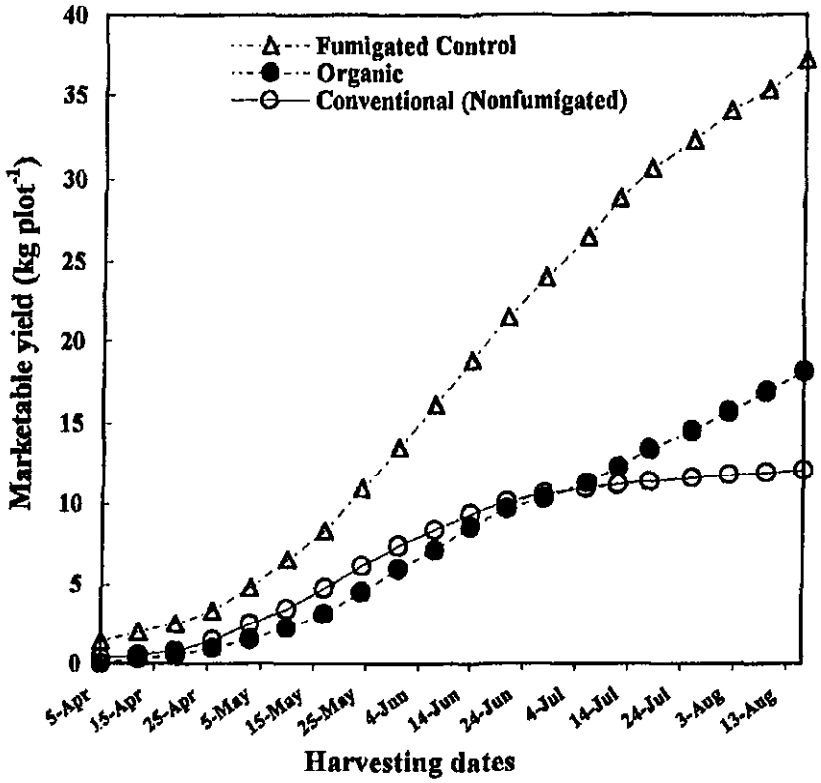


Means with different letter are significantly different at $p<0.05$, n=40

*Disease rating scale: 1=healthy plant, 2=moderately stunted, 3=moderately stunted, slight rossette of dead leaves, 4=moderately stunted, moderate rossette, 5=significantyl stunted, slight rossette, 6= significantly stunted, moderately rossette, 7=significantly stunted,significantly rossette, 8=dead plant

Fig. 1

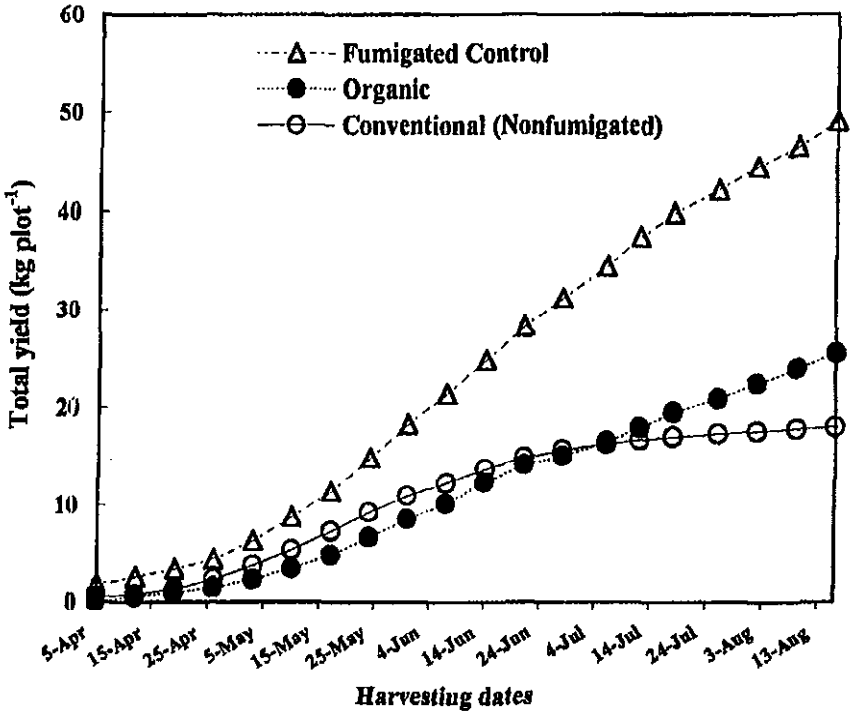
Marketable Strawberry Yield in Conventional and Organic Production System in 2000



*Please note that this is the first year of experiment, so data on the effect of rotation on strawberry yield are not available. The reductions in yield in the organic and nonfumigated conventional plots were caused by the high Verticillium Wilt disease incidence.

Fig. 2

Total Strawberry Yield in Conventional and Organic Production System in 2000



Please note that this is the first year of experiment, so data on the effect of rotation on strawberry yield are not available. The reductions in yield in the organic and nonfumigated conventional plots were caused by the high Verticillium wilt disease incidence.

Fig. 3